Fiber optic hydrophone systems are under development and it is desirable to provide shape sensing that is compatible and that reduces the cost of the shape sensing.

An alternative way to determine array shape is by curvature sensors and either roll or twist sensors. Roll sensors have the advantage of sensing an absolute parameter at each point measured.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a fiber optic sensing device which may be used as a fiber optic roll sensor or as a fiber optic pitch sensor.

It is yet another object of the present invention to provide a fiber optic sensing device which may be used as a fiber optic roll sensor or as a fiber optic pitch sensor in a towed array.

It is a further object of the present invention to provide a sensing device as above which is simple and relatively inexpensive.

The foregoing objects are attained by the sensing device of the present invention.

In accordance with the present invention, a sensing device is provided which may be used as a roll sensor and/or as a pitch sensor. The sensing device broadly comprises at least one optical fiber supported in a structure, a movable mass supported

within the structure, and means for detecting changes in tension in the at least one optical fiber due to movement of the movable mass. The only deformable structure in the sensing device of the present invention is the optical fiber(s), thereby maximizing sensitivity.

Other details of the sensing device of the present invention, as well as other objects and advantages attendant thereto, are set forth in the following detailed description and the accompanying drawings wherein like reference numerals depict like elements.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of a sensing device in accordance with the present invention;

FIG. 2 is a sectional view of the sensing device of the present invention taken along lines 2 - 2 in FIG. 1;

FIG. 3 shows an alternative embodiment of the sensing device of the present invention; and

FIG. 4 shows yet another alternative embodiment of the sensing device of the present invention.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

A first embodiment of the sensing device of the present invention is shown in FIGS. 1 and 2. As shown therein, the

sensing device 10 has a plurality of optical fibers 12 strung under tension inside a cage 14.

The side wall 17 of the cage 14 has a plurality of notches 15. The notches 15 serve two purposes. First, they keep the optical fibers 12 radially distributed in an even manner around a mass 16. Second, the notches 15 provide a space so that the optical fibers 12 are not crushed between the cage 14 and the mass 16 during shock events. Instead, the outside surface 40 of the mass 16 contacts the inside surface 41 of the cage 14, limiting the travel without crushing any of the optical fibers 12.

While FIG. 2 shows the notches 15 in the side wall of the cage 14, they could alternatively be located in the mass 16, instead of the cage, as shown in FIG. 3.

As can be seen from FIGS. 1 and 2, the mass 16 is suspended within a portion 19 of the cage 14 by the surrounding optical fibers 12. The mass 16 is initially in contact with all of the optical fibers 12. This places each of the optical fibers 12 in a prestrained state. If the device 10 is disposed vertically, all of the optical fibers 12 have the same prestrain. When the device 10 is disposed horizontally and rolls, the relationship of the optical fibers 12 and the mass 16 to the axis of the gravitational field changes. The optical fiber or fibers 12 on the bottom bear more weight and are strained greater than their